

Evaluation of an Adaptive Ramp Metering System on I-880 in San Francisco Bay Area

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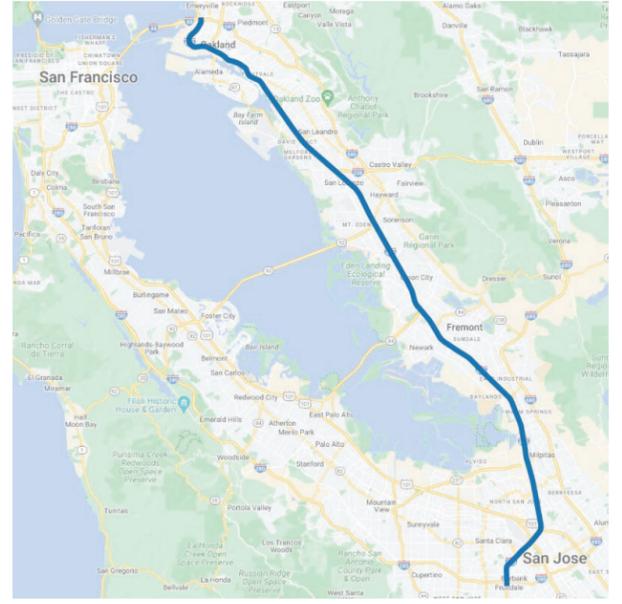
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Study Corridor

The Interstate 880 (I-880) Corridor, stretching between the I-280 Interchange in Santa Clara County and the West Grand Ave on-ramp in Alameda County, serves as the primary north-south freeway route in the San Francisco Bay Area. Traditional local responsive ramp metering was implemented on the I-880 corridor. Since May 2022, Adaptive Ramp Metering (ARM) has been progressively implemented on this corridor in five phases, with the final phase completed in September 2022.



Study Purpose

The purpose of this evaluation was to perform a comprehensive evaluation of the ARM system to assess potential benefits on the I-880 corridor. Unlike simulation-based evaluations, this study was performed for a recent field deployment of an ARM system based on Big Data, including INRIX and detector data.

Methodology

The "on/off" approach (or "with/without analysis") was selected for this project. An on/off approach involves turning off ARM for a brief period to gather data for the "without" condition, and then turning it back on again. The on/off approach provides a more objective evaluation since it minimizes the influence from external factors such as post-pandemic recovery and seasonal variations. Unlike a traditional before/after analysis, the on/off approach enables the collection of comparative data just weeks apart, compared to the "before" and "after" data which are typically months or years apart.

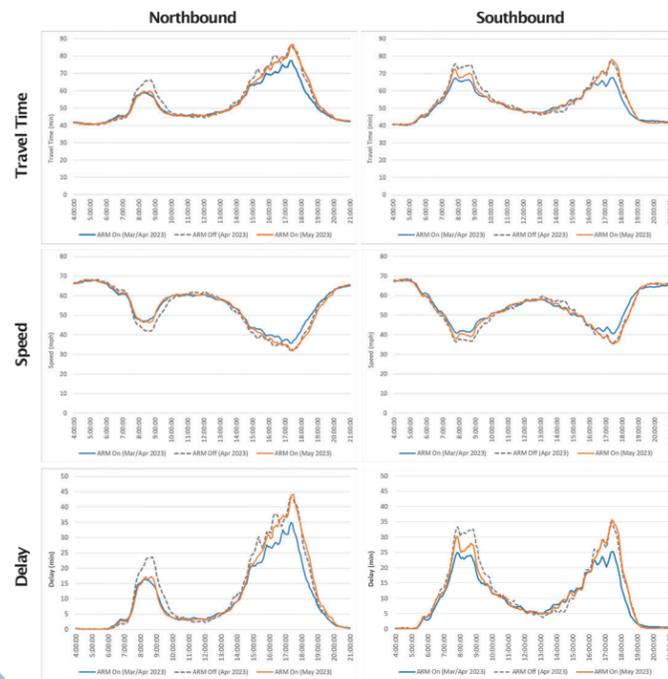
- ARM On: March 20 - April 14, 2023
 - ARM Off: April 17 - 30, 2023
 - ARM On: May 1 - 26, 2023
- The data used for this evaluation were compiled from the following sources.
- INRIX Roadway Analytics
 - Caltrans Performance Measurement System (PeMS)
 - Advanced Traffic Management System (ATMS)

Abstract

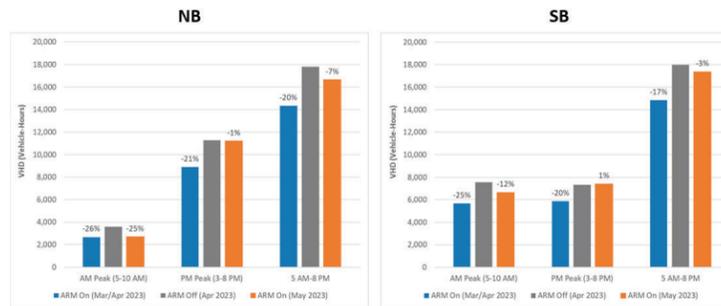
Simulation-based ramp metering evaluation studies have been conducted and have offered helpful insights. However, very few field assessments have been performed in the past to evaluate adaptive ramp metering (ARM) systems. There is a gap in understanding the actual benefits of an ARM system based on real data, not simulated data. This paper presents an evaluation of the adaptive ramp metering system deployed on Interstate 880 (I-880) in the San Francisco Bay Area, a 45-mile corridor with 136 on-ramps in both directions. The "on/off" approach, which involves turning off ARM for a brief period to gather data for the "without" condition and then turning it back on again, provides a more objective evaluation since it minimizes the influence from external factors such as post-pandemic recovery and seasonal variations. Unlike simulation-based evaluations, this study was performed for a recent field deployment of an ARM system based on Big Data, including INRIX and detector data. The ARM system deployed on I-880 has demonstrated notable improvements based on the performance measures used in this study. It was found that on mid-weekdays, ARM reduced travel time by 4%, increased speed by 3%, reduced delay by 16%, decreased vehicle hours of delay (VHD) by 16%, and reduced bottleneck congestion levels by 18%. This study provides valuable insights into potential benefits of adaptive ramp metering systems within urban freeway environments.

Evaluation Results

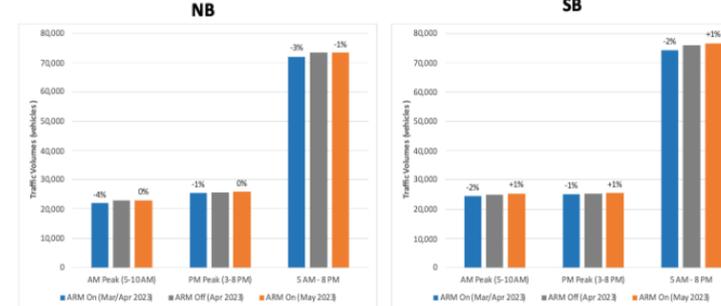
- Travel Time, Speed, VHD, Bottlenecks, Congestion Level



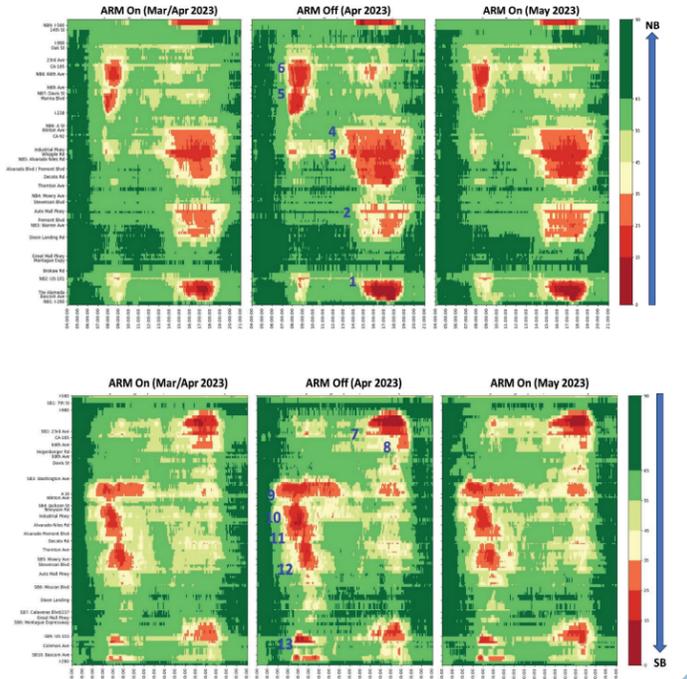
VHD by Time Period



Traffic Volumes



Speed Heatmap



Summary of Corridor Performance Measures

Time Period	Scenario	Avg. Travel Time	Avg. Speed	Avg. Delay	VHD
AM Peak (5-10 AM)	ARM On (Mar/Apr 2023)	-5%	4%	-24%	-25%
	ARM On (May 2023)	-4%	3%	-20%	-19%
	Average	-5%	3%	-22%	-22%
PM Peak (3-8 PM)	ARM On (Mar/Apr 2023)	-7%	6%	-20%	-20%
	ARM On (May 2023)	0%	0%	0%	0%
	Average	-3%	3%	-10%	-10%
Average		-4%	3%	-16%	-16%

Conclusions

This paper contributes to the understanding of adaptive ramp metering systems' effectiveness in urban freeway settings, using I-880 as a case study. Through comprehensive data analysis and performance evaluation, the study highlights the benefits of adaptive ramp metering in improving freeway operations.

- **Travel Time and Speed:** Overall, average travel time decreased by 4% and average speed increased by 3%. Travel time and speed improved more in March/April 2023 than in May 2023.
- **Delay:** Average delay decreased by 16%. Delay decreased more in March/April 2023 than in May 2023.
- **VHD:** Average VHD decreased by 16%. VHD decreased more in March/April 2023 than in May 2023.
- **Overall congestion levels** were reduced by 26% in March/April, and 9% in May.

Although the "on/off" approach used in this study provides a more objective evaluation since it minimizes the influence from external factors such as post-pandemic recovery and seasonal variations, it is important to understand that there are other confounding factors. Other than ARM, other factors such as changes of traffic volumes and congestion on the nearby corridors can also influence traffic conditions on I-880. Data analysis showed that traffic volumes on SB I-880 increased in May 2023. In addition, the SB US-101 bottleneck near the I-880 interchange experienced longer duration of congestion and longer queue in the PM peak period. The increased US-101 traffic and the un-metered traffic flow from US-101 might have also increased delay on I-880 in this area.

In conclusion, the adaptive ramp metering system deployed on I-880 has demonstrated notable improvements in the performance measures used in this study, including travel time, speed, delay, congestion level, and VHD. This study provides valuable insights into the potential benefits of adaptive ramp metering systems within urban freeway environments.